Aquifer-System Characterization Using Interferometric Synthetic Aperture Radar

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ABSTRACT

Interferometric synthetic aperture radar (InSAR) is a powerful technique that uses radar data acquired at different times to measure land-surface deformation, or displacement, at an unprecedented level of spatial detail and high degree of measurement resolution. Two SAR scenes are combined to form a "change" interferogram; the change is determined by differencing or "interfering" two radar scans made of the same area at different times.

InSAR displacement maps, in conjunction with other hydrogeological data, have been used to determine aquifer-system characteristics where surface deformation is the result of stress-induced changes in the granular skeleton of the aquifer-system. In Santa Clara Valley, California, displacement maps and water-level data have shown that land-surface changes caused by aquifer-system deformation are elastic (reversible): during the summertime when water levels are declining, the land surface subsides, and during the wintertime when water levels are recovering, the land surface uplifts. In Las Vegas Valley, Nevada, displacement maps used with fault maps have shown that the extent of regional land-surface changes caused by aquifer-system deformation may be controlled by major faults. At Yucca Flat, Nevada, displacement maps detected subsidence associated with the recovery of elevated hydraulic heads caused by weapons testing at depths in excess of 600 meters.

For these selected case studies, continuing or renewed deformation of the aquifer system is coupled with pore-fluid pressures. When applied stresses (water levels) can be measured accurately for periods when InSAR maps show displacement, stress-strain relations, and thus storage properties, may be evaluated. For areas where additional data is needed, displacement maps can be used as a guide to design appropriate monitoring networks. Aquifer-system properties derived from stress-strain relations, and the identification of hidden faults and other hydrogeologic boundaries in the flow system can be used to constrain numerical ground-water flow and subsidence simulations. Managing aquifer systems within optimal limits may be possible if regions susceptible to land-surface displacement can be identified and characterized.